Extremely Metal-poor Emission-line Galaxy Survey with Subaru/HSC

Takashi Kojima (Univ. of Tokyo)

M. Ouchi, M. Hayashi, M. Rauch, K. Yabe,
M. Umemura, H. Kitagawa, T. Amagasa, T. Nagao,
S. Fujimoto, T. Hashimoto, Y. Harikane, R. Higuchi, R. Itoh,
J. H. Kim, Y. Komiyama,
C.-H. Lee, Hilmi Miftahul, D. Miura, Y. Ono, T. Shibuya

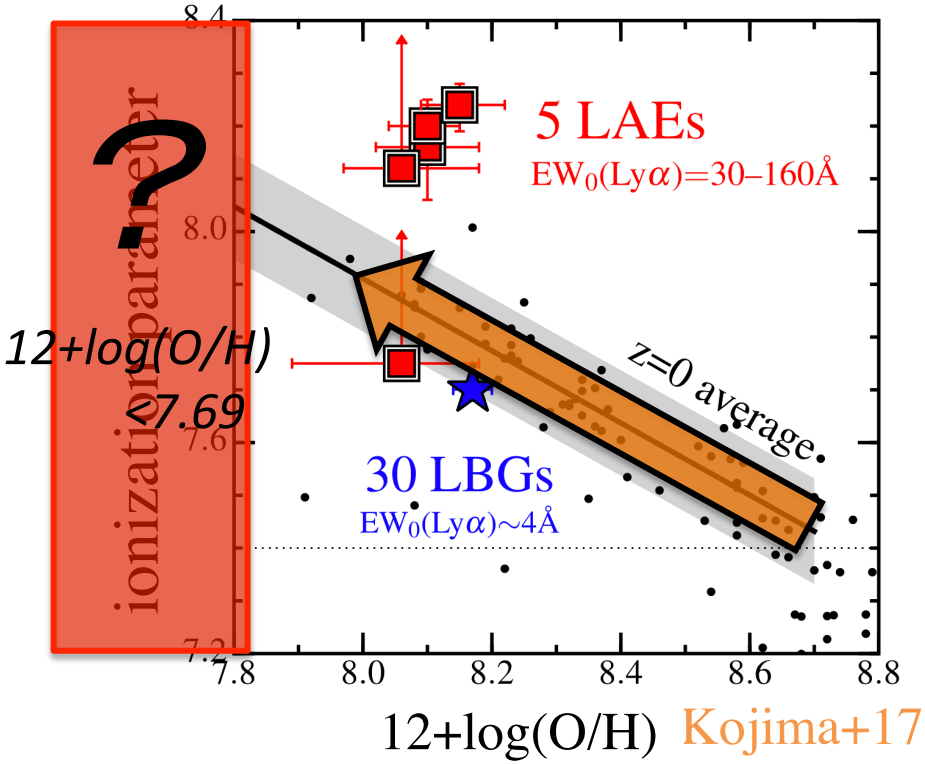
Extremely Metal-Poor strong-line Galaxy (EMPG)

- Dominant population in the early universe
- Highly ionized → leaking ionizing photons?

def. 12+log(O/H)<7.69
$EW_0(H\alpha)$>800Å

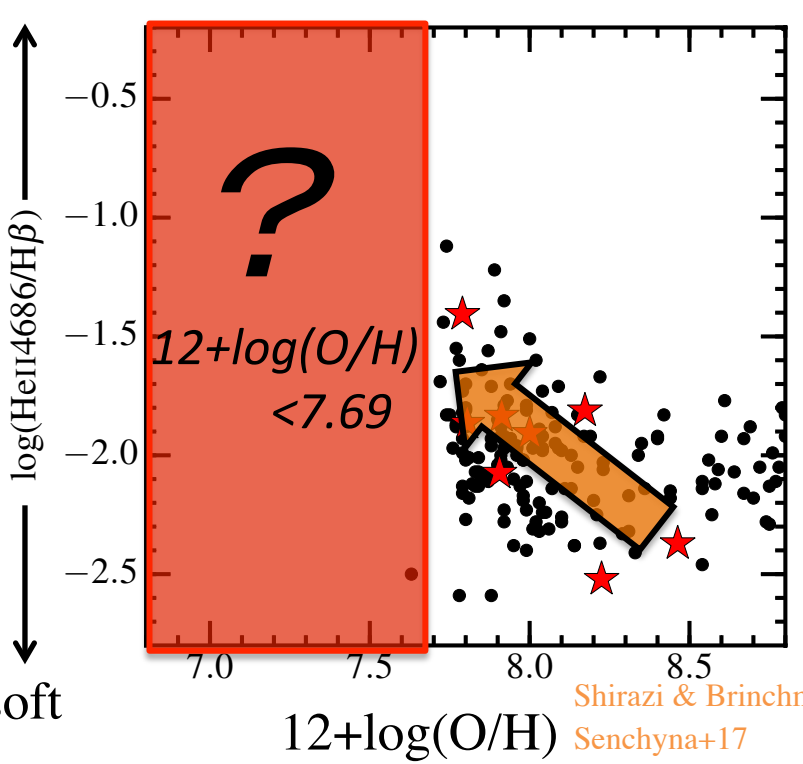
Izotov+16b [12+log(O/H)~7.8-8.0]

high ionization parameter



Kojima+17

hard EUV radiation



Shirazi & Brinchmann 2012
Senchyna+17

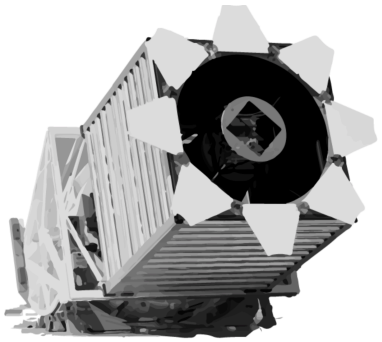
EMPGs (z<0.06) → Intense, hard EUV radiation ?

Advantages of this study ① (data depth)

[Prev.] SDSS (Sloan Digital Sky Survey)

e.g., Izotov+12
Sanchez-Almeida+16

$i_{limit} \sim 21$ mag



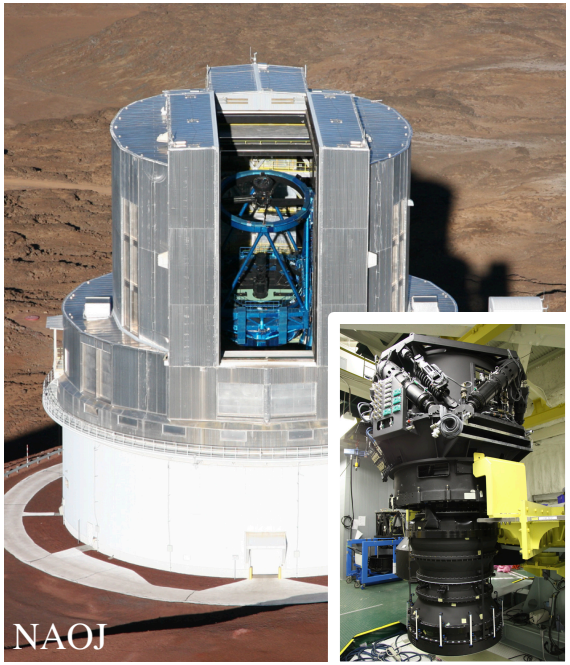
SDSS

~5-7 mag deeper

[This work] Subaru/HSC SSP data

i_{limit} **~ 26–28 mag**

$M_* = 10^4$–$10^6\ M_{sun}$

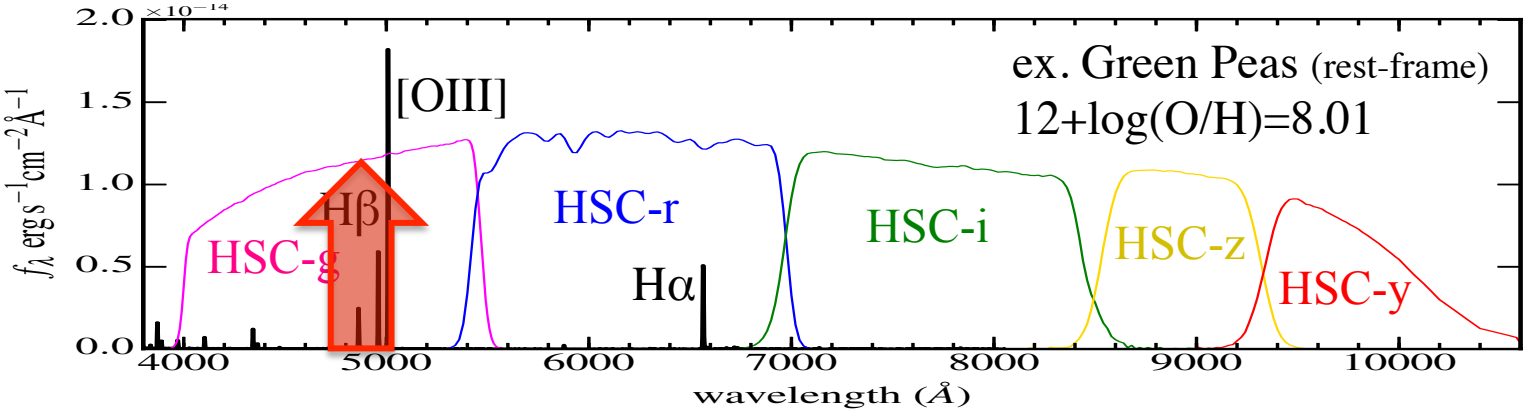


→ We'll find EMPGs that cannot be discovered in the SDSS data

Advantages of this study ② (selection)

- Select with broad-band photometry excess

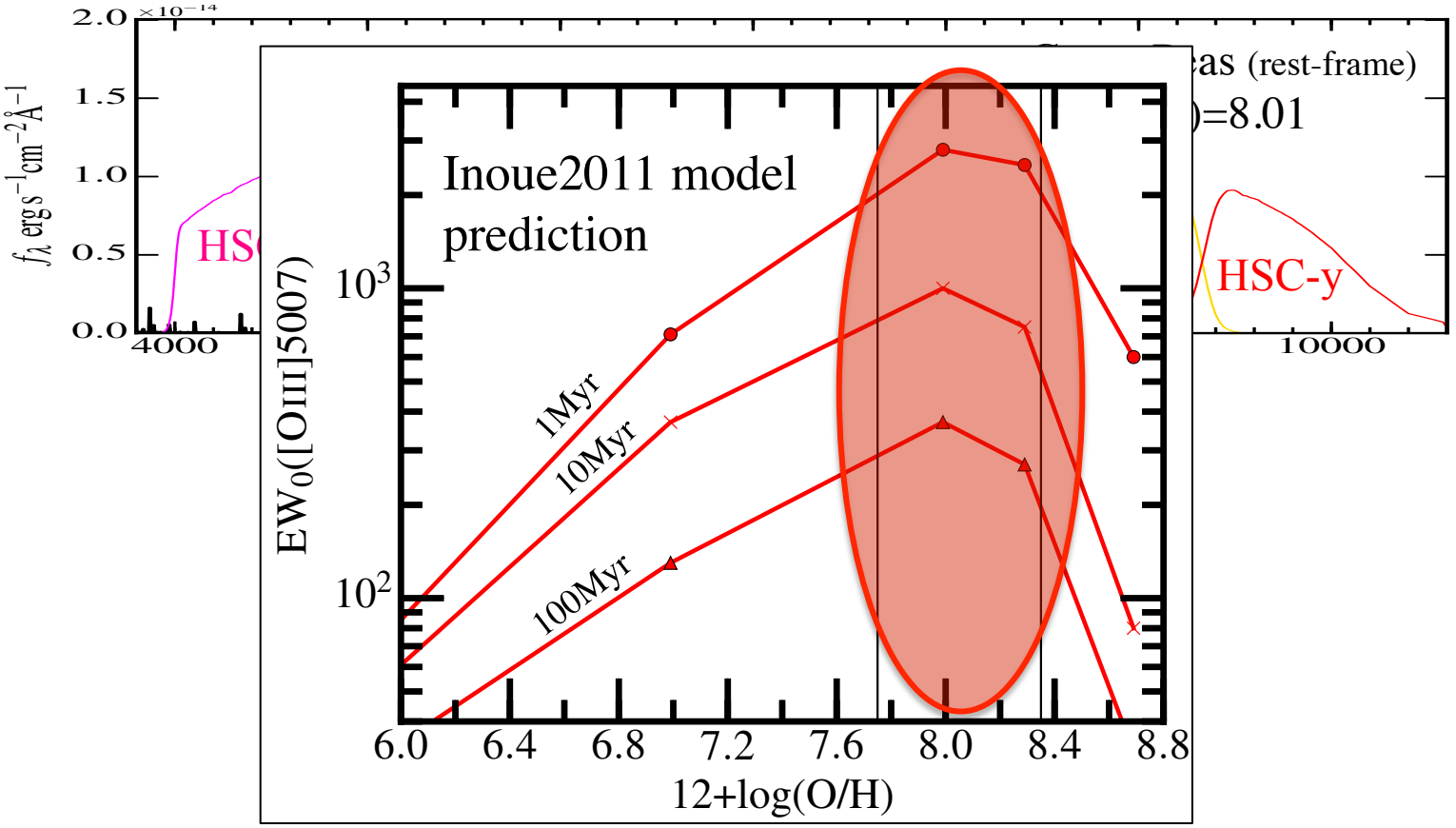
[Prev.] Very strong [OIII]5007Å (GPs/BBs)



Advantages of this study ② (selection)

- Select with broad-band photometry excess

[Prev.] Very strong [OIII]5007Å (GPs/BBs) → Bias to 12+log(O/H)~8.0

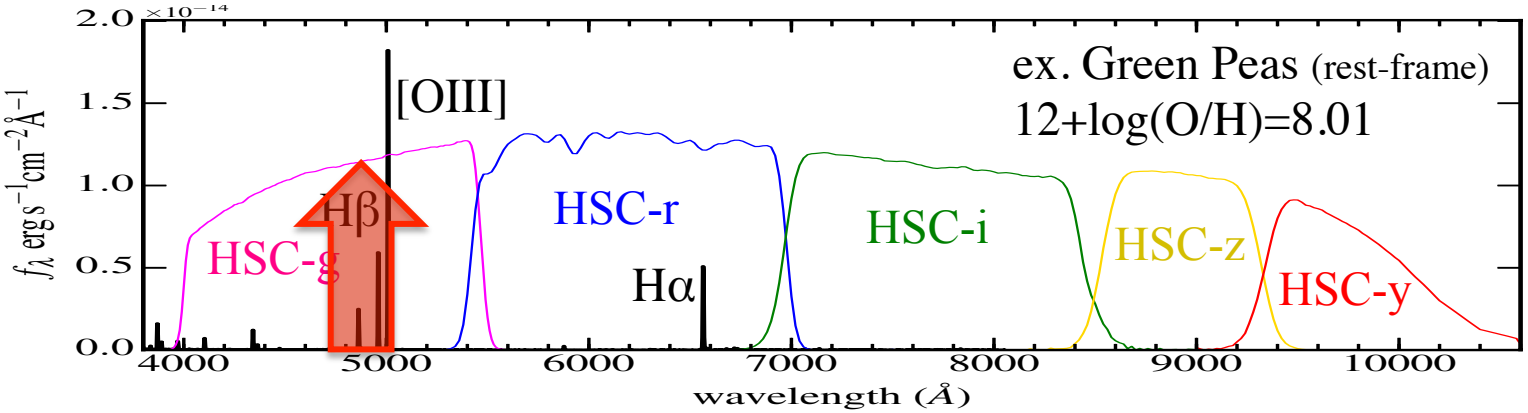


The selection based on a strong [OIII] is successful (GP/BB) but **not ideal to reach 12+log(O/H)<7.0**.

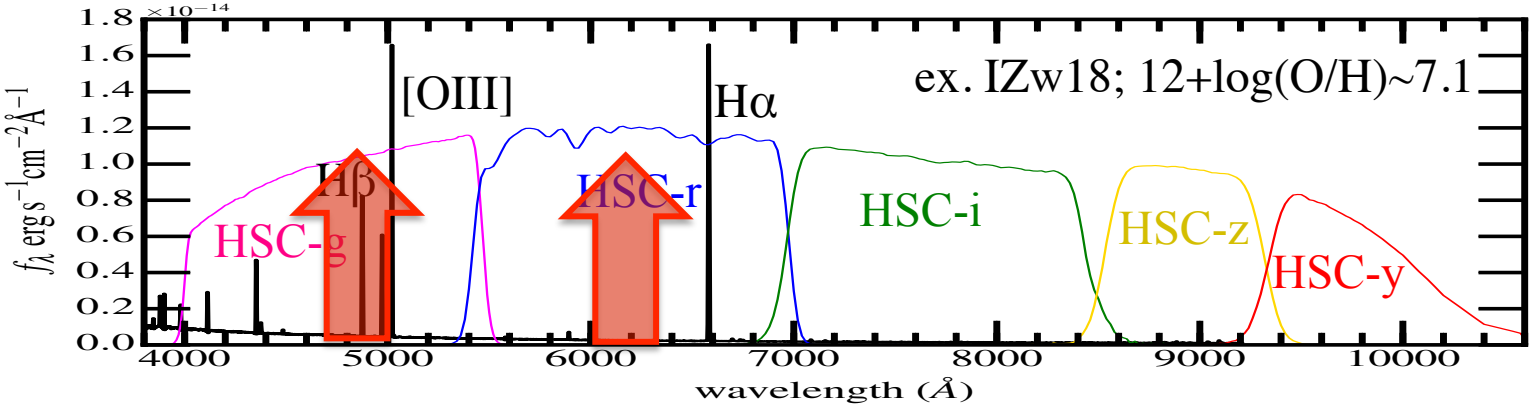
Advantages of this study ② (selection)

- Select with broad-band photometry excess

[Prev.] Very strong [OIII]5007Å (GPs/BBs) → Bias to 12+log(O/H)~8.0



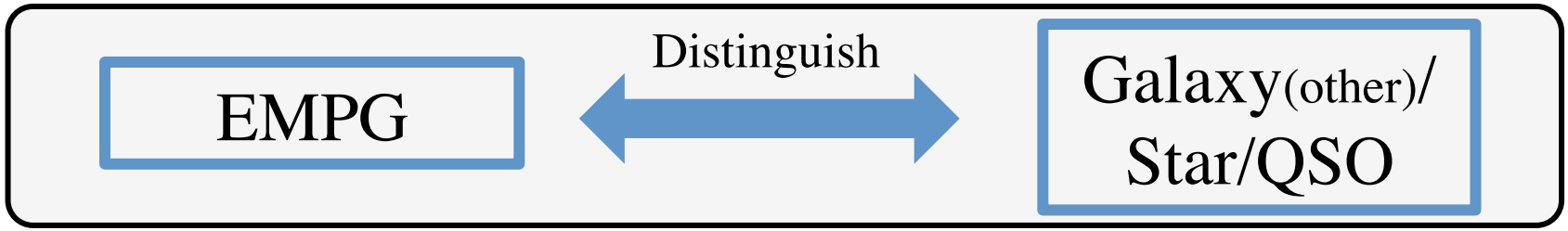
[This work] Multiple lines + blue cont. → Down to 12+log(O/H)<7.0 !!



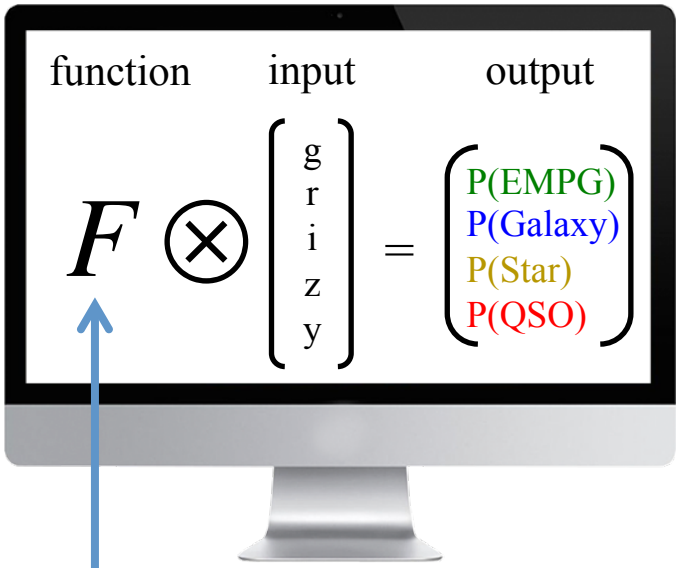
Problem: complex color → Solved by Deep Learning!

EMPG selection by Deep Learning

- Basic idea is…



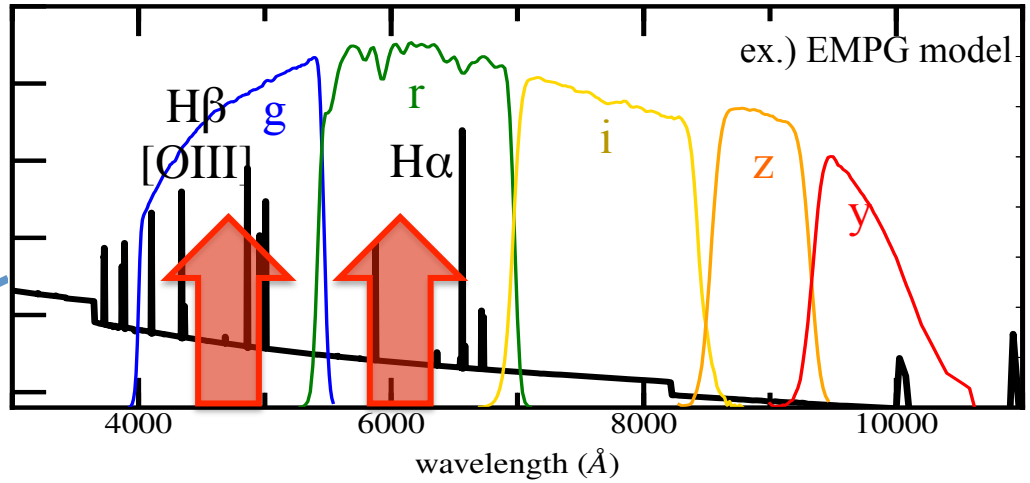
Classifier ← Deep Learning



Trained with SED models
(optimized)

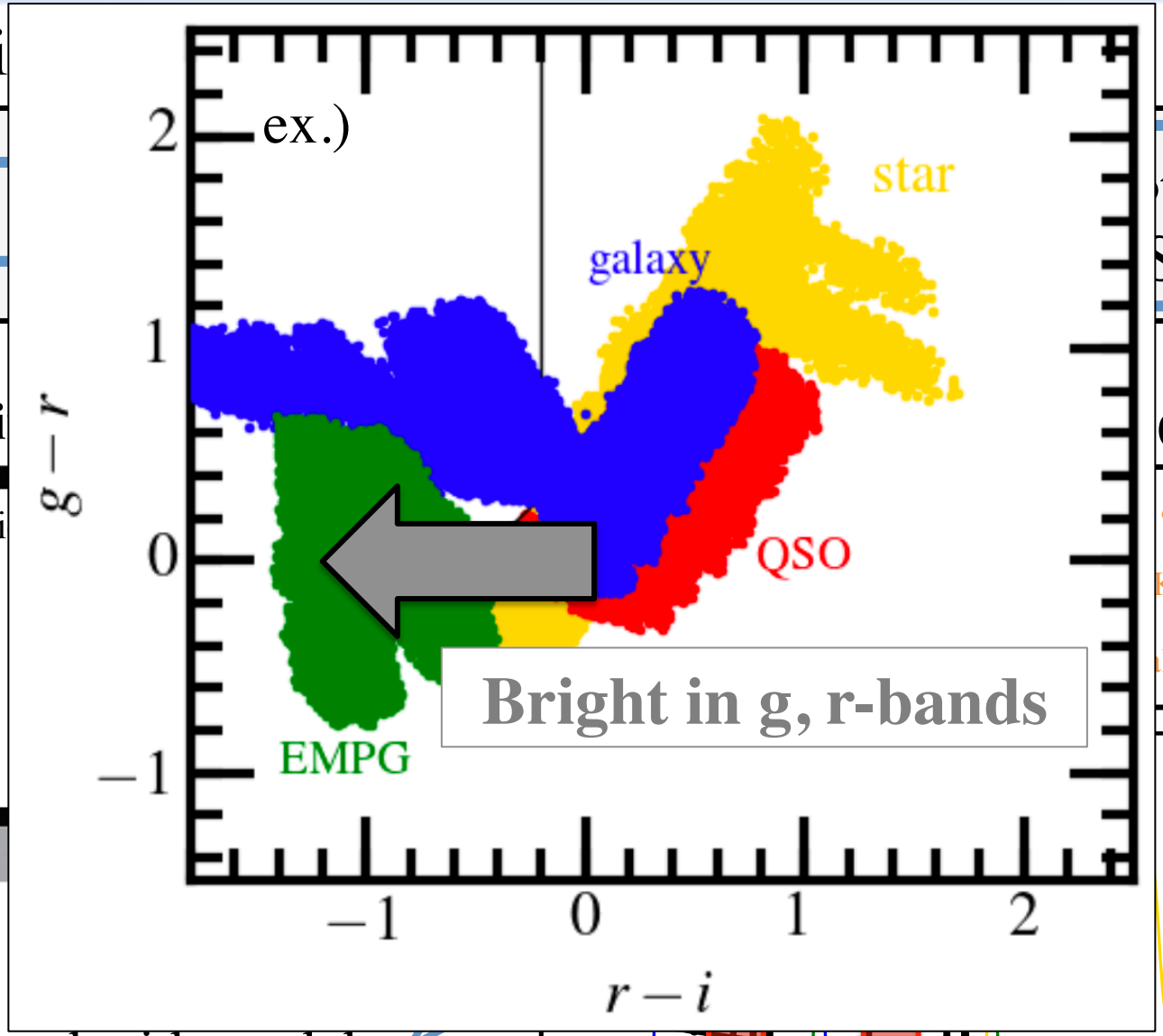
SED models (30,000×4)

Beagle	Chevallard & Charlot 2016
Stellar model	Castelli & Kurucz 2004
QSO composite	Selsing et al. 2016



EMPG selection by Deep Learning

- Basi



Classi

functi

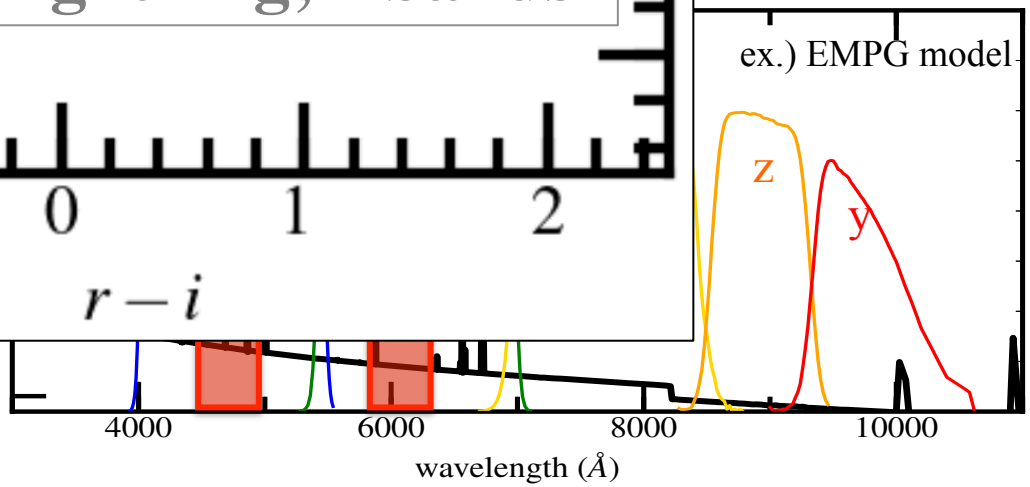
F

Optimized with models

& Charlot 2016

Kurucz 2004

l. 2016



Test our method with SDSS data (w/spectrum)

SDSS Data — Total: 935,042 objects

×: Not deep, ○: w/spectra

← Apply our method

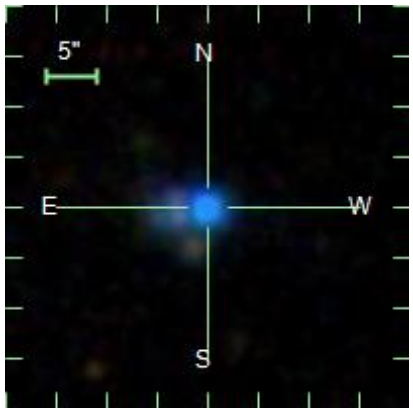
13 candidates

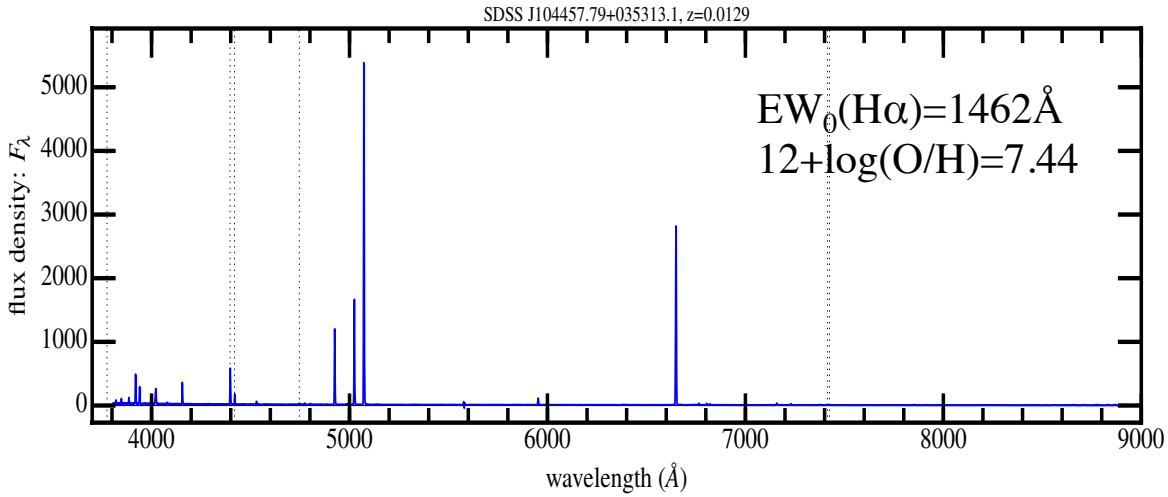
← Check the answers with spectra

6 EMPGs / 7 MPGs

Our selection ➔ **Successful**

One example of EMPGs





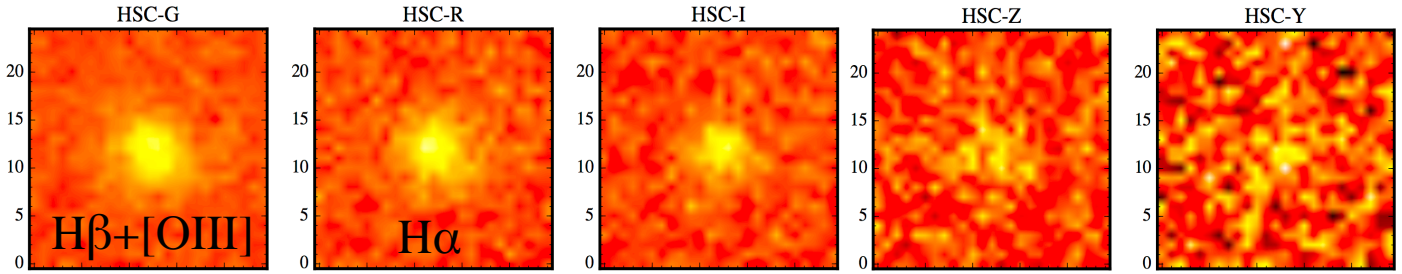
Apply our method to the HSC-SSP data

HSC data (Survey area; ~100 deg^2; i_{lim}~26-28)

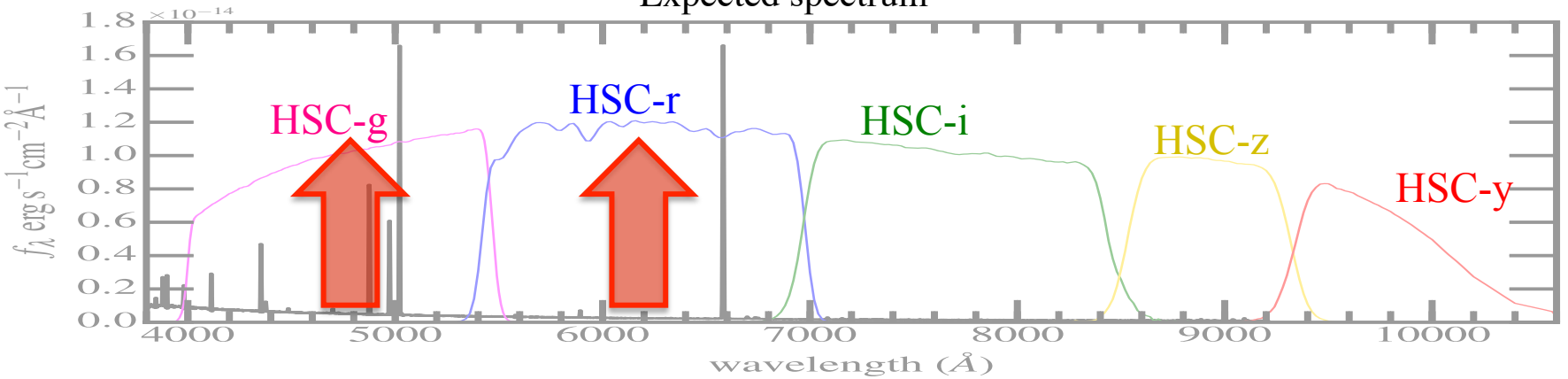
↓ ← apply our method

5 candidates (→ ~50 expected when the HSC-SSP is completed)

One example



Expected spectrum

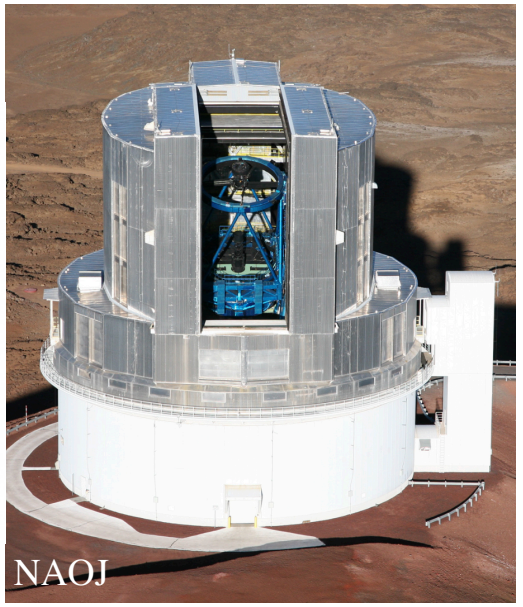


Spectroscopy for the EMPG candidates

- Subaru/FOCAS

  Collaboration with Yoshiaki Ono

  Cancelled



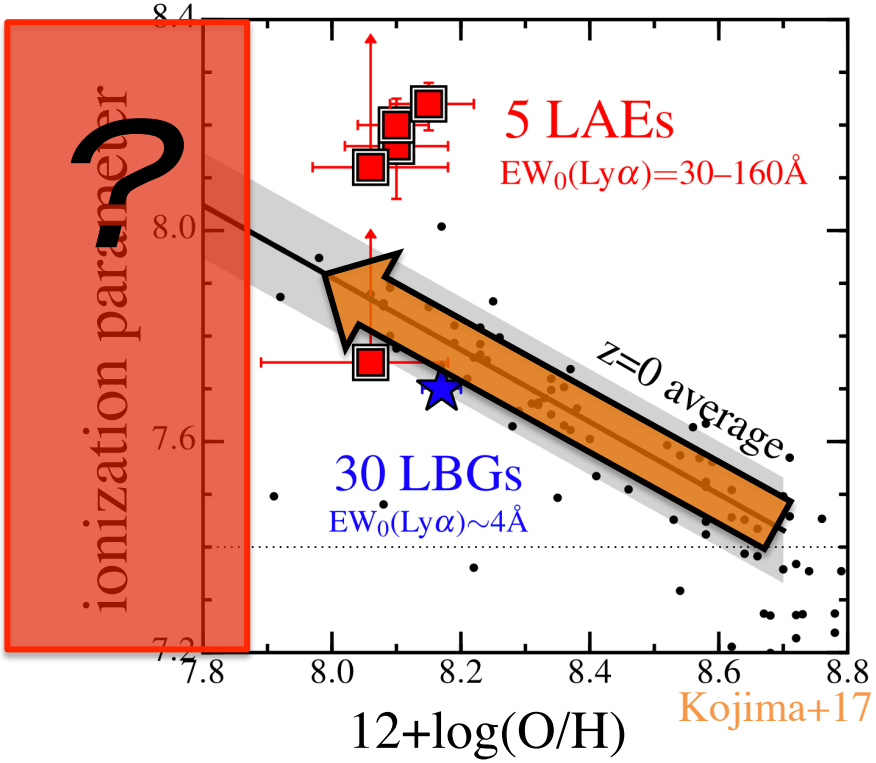
- Magellan/LDSS3+MagE

  Collaboration with Michael Rauch

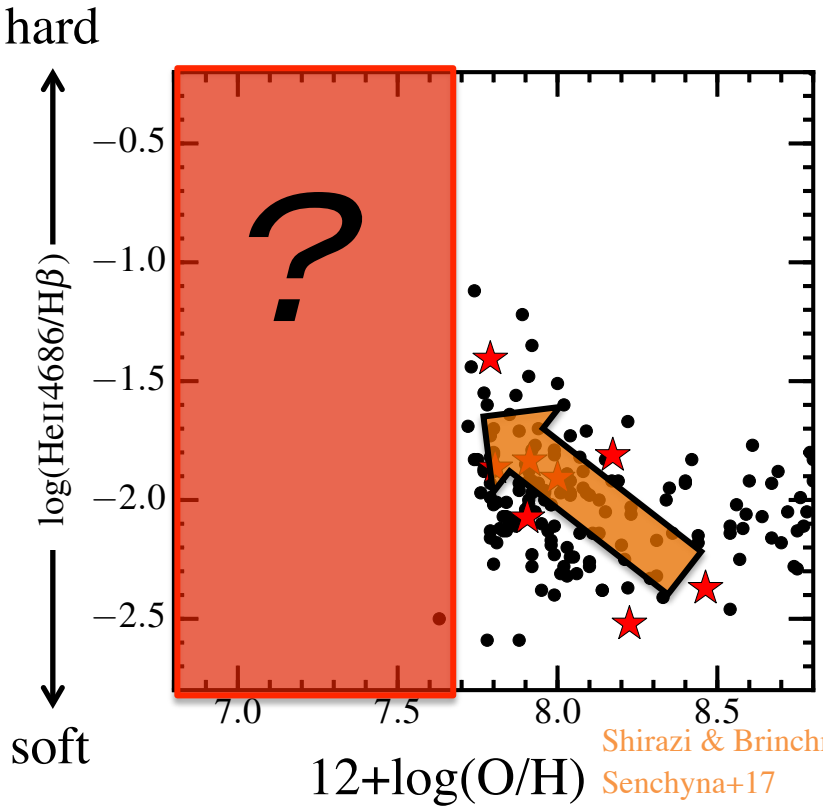
  (April & June, 2018)

Q. How intense, hard EUV radiation in the very low Z?

high ionization parameter?



hard EUV radiation?



HSC-EMPG: $M_*=10^{4\text{-}6}\,M_{sun}$, very young, & **$Z/Z_{sun}$=1-10%**

→ good sample to investigate the EUV radiation

Summary:

Extremely Metal Poor Galaxy (EMPG) Survey

Q. EMPG → Intense, hard EUV radiation?

Wide, deep imaging data (Subaru/HSC-SSP)	+	Deep Learning (DNN)

* SDSS data test → successful (6 EMPGs, 5 MPGs)

Our technique is effective to select EMPGs

* HSC data → 5 EMPG candidates selected
* Follow-up optical spectroscopy very soon

Stay tune…